high pulse repetition rate with the duration of each pulse being in the order of about 1 femtosecond to less than 50 picoseconds so that energy deposition is localized to a small depth and occurs before significant hydrodynamic motion and thermal conduction which can lead to collateral damage.

The invention of the present application is directed to a method for controlled variable rate material modification by controlling the power density of the electromagnetic radiation beam. The electromagnetic radiation beam may come from a continuous wave (CW) source or a pulsed source. The material modification includes a range of chemical and physical changes in the material, besides tissue removal.

Specifically, Claim 35 recites "control of power density is achieved by varying either one or more of the following parameters:... by spatially and temporally varying the absorption and/or scattering characteristics of the material at the targeted region". The *Neev, et al.* '894 patent does not teach or contemplate achieving control of power density by spatially and temporally varying the absorption and/or scattering characteristics of the material at the targeted range. Claim 35 further requires "allowing interaction energy transients caused by the electromagnetic radiation pulse to substantially decay so that material modification is affected". The *Neev, et al.* '894 patent does not teach nor does it contemplate allowing interaction energy transients caused by the electromagnetic radiation pulses to substantially decay so that material modification is affected. Such interaction energy transients, which may include transient chemical or thermal or mechanical changes tend to interfere with the next pulse effect if present.

The *Neev, et al.* '894 patent only contemplates oblation of tissue. The present invention, on the other hand, contemplates material modification which includes not only

ablation, but one or more of the following material alterations: chemical changes, physical changes, changes to viscoelastic properties, changes to optical properties, thermal properties, chemical and physical breakdown, disintegration, melting and vaporization.

Claim 35 further requires "operating the pulse source at a pulse repetition rate greater than 0.1 pulses per second". The *Neev, et al.* '894 patent recommends a pulse repetition rate of 10 hertz to 1000 hertz. The pulse rate of 0.1 pulses per second (0.1 hertz) is two orders of magnitude smaller than the *Neev, et al.* '894 lower frequency of its range.

Claim 37 requires adding scattering and/or absorption centers, defects, or highly absorbent components, to the target material with spatial and/or temporal selectivity to specific predetermined locations within the target material. Neither the *Neev, et al.* '894 patent, nor any of the references of record disclose or contemplate this step.

The Office Action concludes that it would be inherent that the power density range of Claim 55 and the average power range in Claim 62 could be determined through routine experimentation using other parameters disclosed throughout the *Neev, et al.* '894 patent. Applicant respectfully traverses. The *Neev, et al.* '894 patent contemplates use of very high peak power pulses generated by a laser class known as "ultra-short pulse lasers". The laser pulses range in duration from 1 femtosecond to about 100 picoseconds. There is only one purpose for these pulses, to ablate the tissue. The invention of the present application on the other hand, contemplates material modification by utilizing pulse repetition rate changes, which are outside the *Neev, et al.* '894 pulse range. The material modification contemplated by the invention of the present application, although

including ablation, utilizes a pulse duration that is much longer, over 10 orders of magnitude longer, than the pulses of the *Neev, et al.* '894 patent, all the way up to continuous waves.

The Office Action points to Col. 6, lines 1-14 for the conclusion that the *Neev, et al.* '894 patent indicates that a threshold volumetric power density can be achieved at a desired location below the material surface. Applicant respectfully traverses. This portion of *Neev, et al.* '894 is simply talking about a microscopic insignificant depth, from a real world prospective of approximately one micrometer. The invention of the present application on the other hand, is concerned with depth ranging from a few micrometers up to several centimeters. This is again a factor of four to five orders of magnitude greater than that contemplated in the *Neev, et al.* '894 patent. Moreover, the *Neev, et al.* '894 patent contemplates elimination of energy deposition below that one micrometer depth when it states "formation of a critical density plasma by both multi-photon and collusional ionization processes eliminates significant energy deposition below a depth of approximately that of a wavelength of the laser light when energy deposition...". Clearly, the *Neev, et al.* '894 patent does not teach nor contemplate volumetric power density at a desired location below the material surface.

Claims 55-66 define an invention that utilizes a continuous wave beam to achieve a high precision, highly controllable, variable rate material removal by use of an continuous wave (CW) beam of electromagnetic radiation wherein the interaction between the electromagnetic radiation and the material is such that the material removal depth is approximately equal to the energy deposition depth within the target material. The *Neev, et al.* '894 patent does not contemplate this structure or function. Moreover,

the *Zair* (5,411,502) patent while directed to a system for causing ablation of irradiated material of living tissue is concerned with "not causing necrosis below a predetermined depth". The *Zair* patent does not teach or contemplate a material removal depth which is approximately equal to the energy deposition depth within a target material. The *Zair* patent utilizes a system that moves the energy beam around while ablating the living tissue to control the dwell time of the beam on a given tissue site in order to not cause necrosis below a predetermined depth. The energy from the laser beam deposited in the tissue ablated and thermal damage to the tissue is supposed to be limited to a predetermined depth. The invention of the present application, on the other hand, generates parameters that allow material removal that results in selected energy deposition depths while substantially eliminating all collateral damage. The two concepts are clearly different.

Claims 55-66 are directed to the use of a continuous wave source which is manipulated to distribute it in place. The *Neev, et al.* '894 patent discloses an oscillator and a pulse stretcher to provide a pulse having the same or shorter pulse duration than the desired pulse duration. However, the *Neev, et al.* '894 patent does not teach or contemplate redistributing a continuous beam. The beam time duration characteristics are changed, but not the beam location (that is, where the laser source is pointing). The oscillator and pulse stretches of *Neev, et al.* '894 are part of the energy source that provides at its output the sequence of short pulses to be directed to a target. Although the *Neev, et al.* '894 patent contemplates using the Kerr effect as part of the energy source, i.e., the laser, the Kerr effect is used to generate short pulses.

There are fundamental differences between the *Neev, et al.* '894 patent system and the invention of the present application. The beam characteristics, i.e., time duration, frequency content, spatial location of frequency, and wavelength content in the beam, are not changed in the invention of the present application as they are in the *Neev, et al.* '894 patent. In the invention of the present application, the spatial location of the beam at the target is changed in time to manipulate the distribution of the constant beam output at a specific place on the target, so the beam itself is never affected, only its location on the target tissue is changed. The *Neev, et al.* '894 patent does not teach or even contemplate the use of a continuous wave source, let alone such a manipulation of the continuous wave beam. The *Neev, et al.* '894 patent specifically limits its source to pulses of up to 100 ps. Moreover, in the invention of the present application, the Kerr effect is contemplated as an external element to the energy source as part of the system design to change the beam time and space locations on the target.

The *Neev, et al*, '894 patent contemplates changing the beam energy time distribution by stretching and then recompressing a pulse beam source. The invention of the present application, on the other hand, redistributes a fixed, continuous wave beam, i.e., the beam always remains a continuous wave source, which is entirely different from a pulsed energy beam. This continuous wave beam is redistributed in both time and space at its location on the target to form at least one modified beam comprising a plurality of pulses. In other words, the present invention achieves pulsing not by changing the beam characteristics, but rather by constructing a system that is able to control and change the continuous wave beam location on the target. The *Neev, et al.* '894 patent only allows an operator to change the beam location manually, by moving it

from one target location to the other. The *Neev, et al.* '894 patent disclosure does not teach or contemplate a means for pulsing the system by changing its location at the target or by controlling the output beam spatial or temporal characteristics. Focusing elements, such as a hollow wave guide or articulated arm will not change the pulse structure of the *Neev, et al.* '894 patent beam. The invention of the present application, however, contemplates affecting pulsing of its continuous wave beam by having, for example, at least one optical fiber and at least one hollow wave guide light conductor, so that by moving the source output beam from one to the other, a pulse effect is created. The optical fiber, or hollow wave guide contemplated by the *Neev, et al.* '894 patent is there simply to deliver an already finalized pulsed output beam to its final target location. The two concepts are fundamentally different.

In light of the above amendment and remarks, Applicant believes that all the claims are allowable in light of the art of record and respectfully requests that this application be passed to issue.

I hereby certify that this correspondence is being sent via Express Mail (EV 034864779 US) in an envelope addressed to the Assistant Commissioner for Patents, Washington, D.C. 20231 on April 12, 2002.

By: Marc Fregoso

Marc Fregoso

Signature

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Respectfully submitted,

PRICE AND GESS

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